Evaluation of the GMI Tropospheric Simulations: Preliminary analysis of the tracer simulations

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with thanks to the GSFC core team

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Data used for model evaluation - review

- Ozonesondes – 32 sites
- MOZAIC ozone - 18 locations
- Surface CO from CMDL, 1992-1997
- MOZAIC CO profiles - 3 locations
- Column CO data
- Aircraft data for CO, NO, HNO_3, PAN, H_2O_2, HCs, from field campaigns (e.g., NASA GTE)

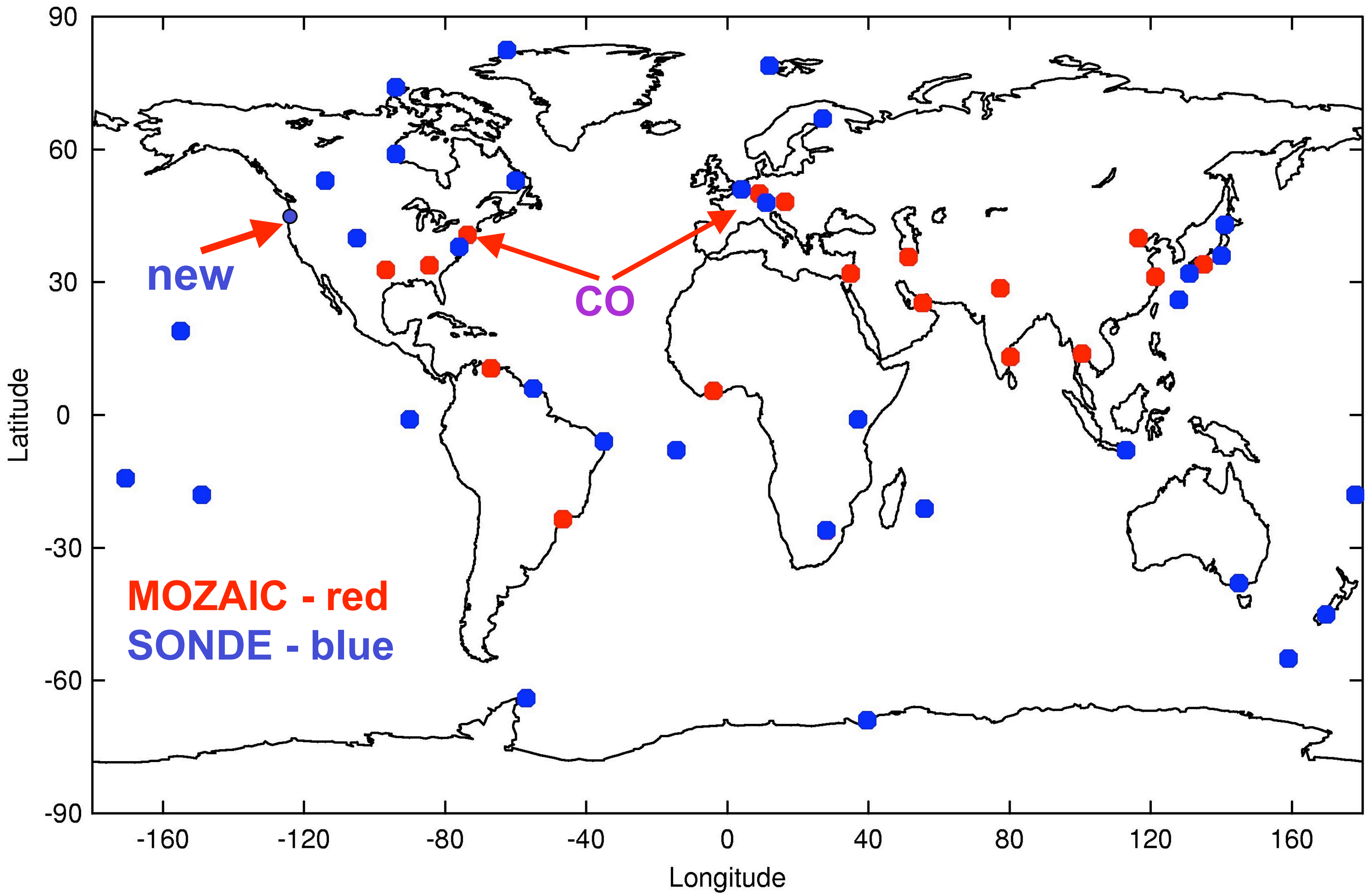
MOZAIC data available up to Feb. 2003. There are many more CO measurements still to be released.

Basic evaluation uses "climatological" data, to examine general characteristics of model, and compare simulations with different met. fields

More focused evaluation will use data matched in time, when using assimilated met. data.

Locations of ozone profiles used for model evaluation

MOZAIC provides data for 20º-40ºN, in the U.S., the Middle East, south and east Asia. Also Africa, S. America.



How to best evaluate model performance, given the large number of model-data comparisons - 50 sites for ozone?

Apply objective criteria

These are used here to

- Evaluate different sets of dynamics (GMI)

Other applications

- Quantify improvement in model performance (GMI, GEOS-CHEM)

For ozone and CO, we examined:

- Mean bias
- Absolute bias
- Amplitude of the seasonal cycle
- The phase of the seasonal cycle

Recent Progress

We repeated the standard evaluation of the GMI full chemistry runs of September 2004

Main changes in results:

- OH is smaller, in better agreement with MCF lifetime
- CO is higher (it was too low before)

To be presented here:

- Brief review of results, with preliminary analysis of the causes for the differences among the 3 simulations, using the tracer runs and diagnostics

Tracer runs and diagnostics

- CO - fossil fuel/industry, 60 day lifetime
- CO - biomass burning, 60 day lifetime
- CO_2 - fossil fuel

- CH_3I - marine source, 5 day lifetime
- Marine tracer - uniform source, 5 day lifetime

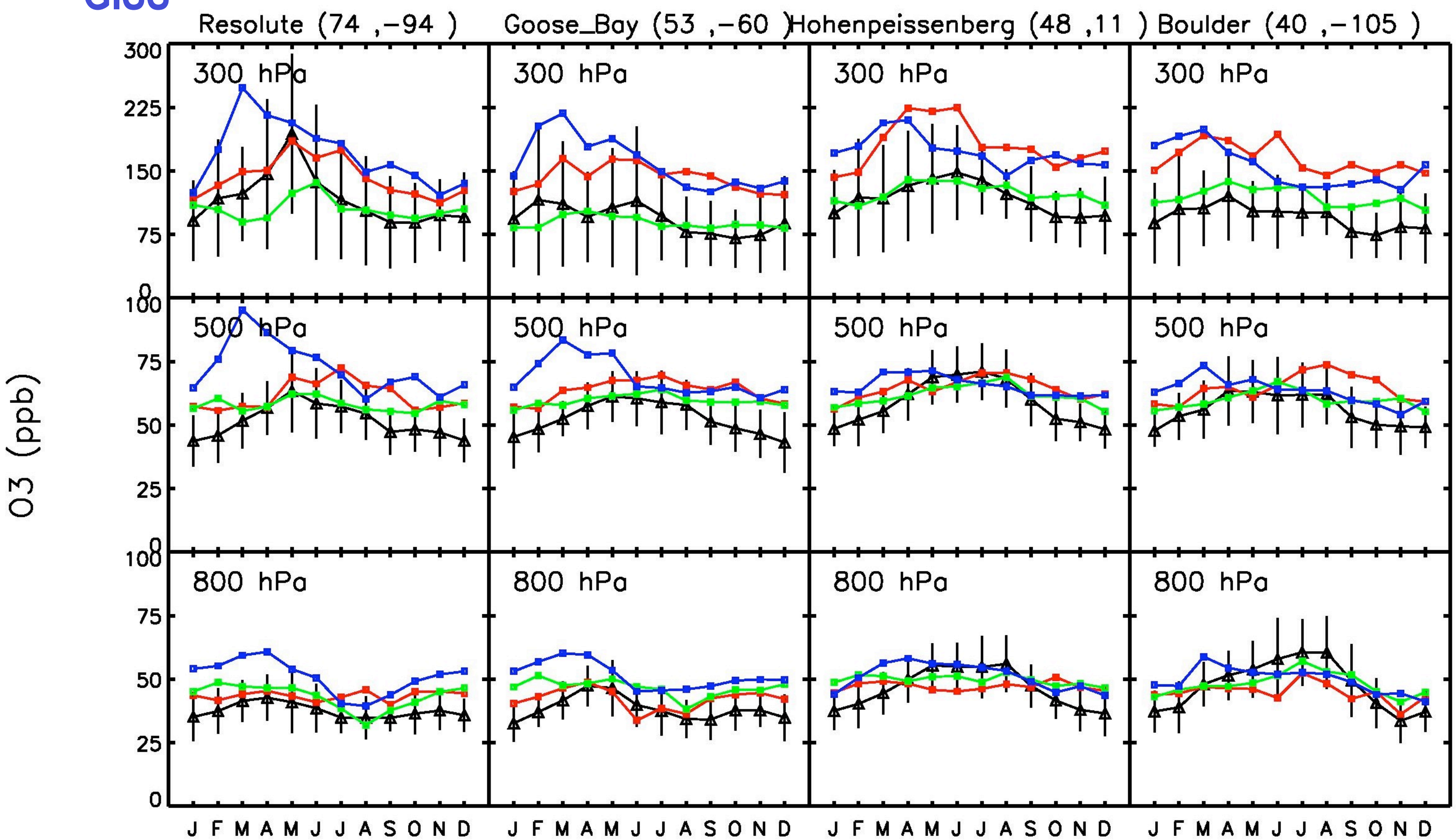
- Rn

Diagnostics include monthly vertical fluxes, and monthly cumulative tendencies for:

- Emissions, convection, advection (total, not in 3 directions), diffusion, dry deposition, wet deposition, chemistry
- No term for accumulation of tracer (can be calc. from restart files), or for loss (simple tracer runs).

Ozone at mid-high latitudes

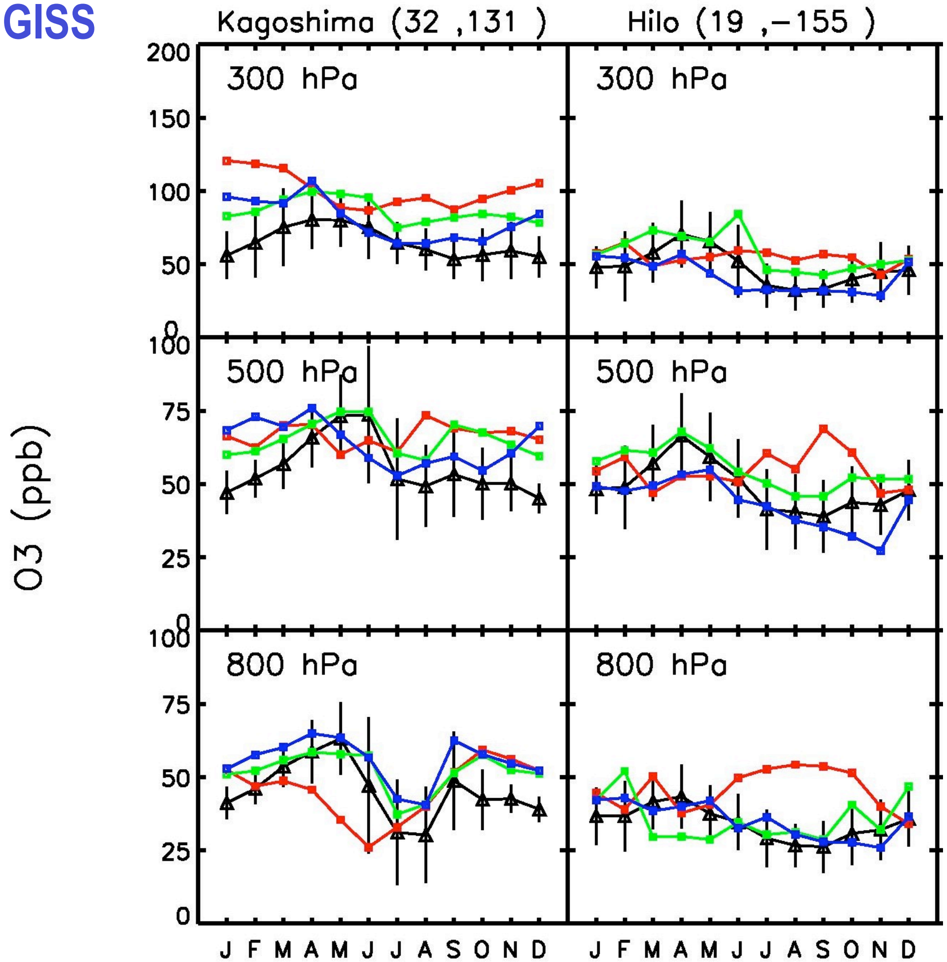
CCM3
DAO
GISS



GISS has problem of too much ozone from the strat. at high latitudes. DAO, CCM3 have damped seasonal cycle at 500 hPa. CCM3 has seasonal maximum too late at lower latitudes.

Ozone in the sub-tropics: SE Asia to Hilo

CCM3
DAO
GISS



Observations show a steep drop from June to July at all sonde and MOZAIC sites

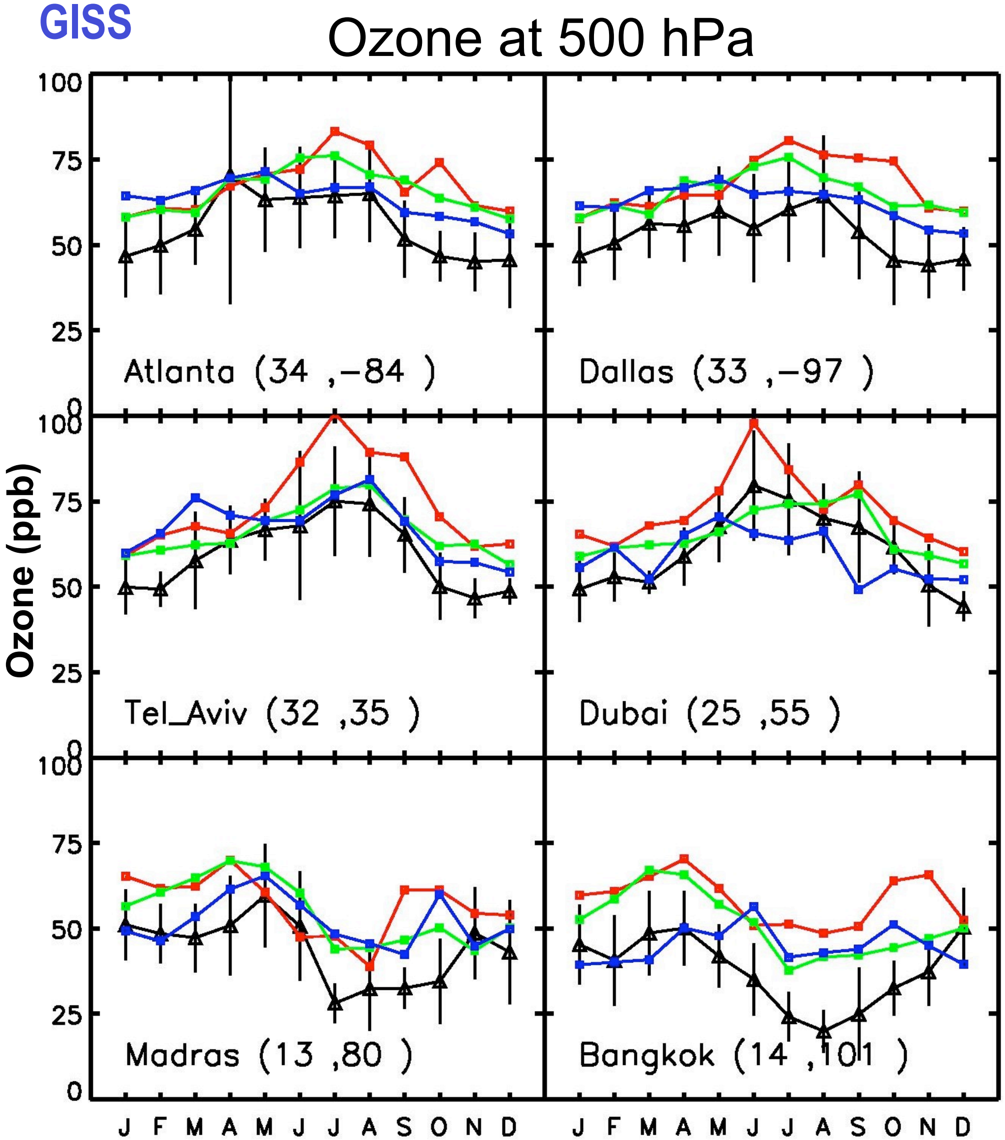
None of the models do this.

CCM3 is the worst.

Need to examine monsoon circulation

CCM3
DAO
GISS

Ozone in the sub-tropics: US, Middle East



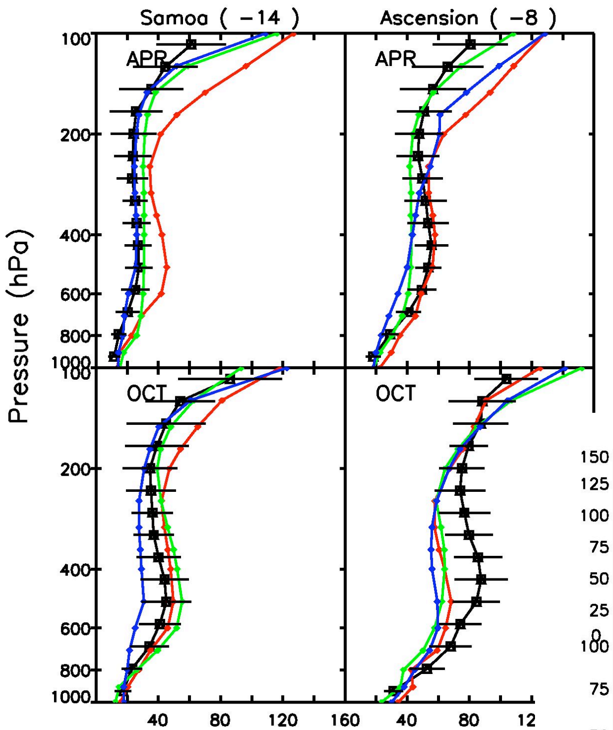
CCM3, DAO: ozone too high in summer over southern US, Middle East

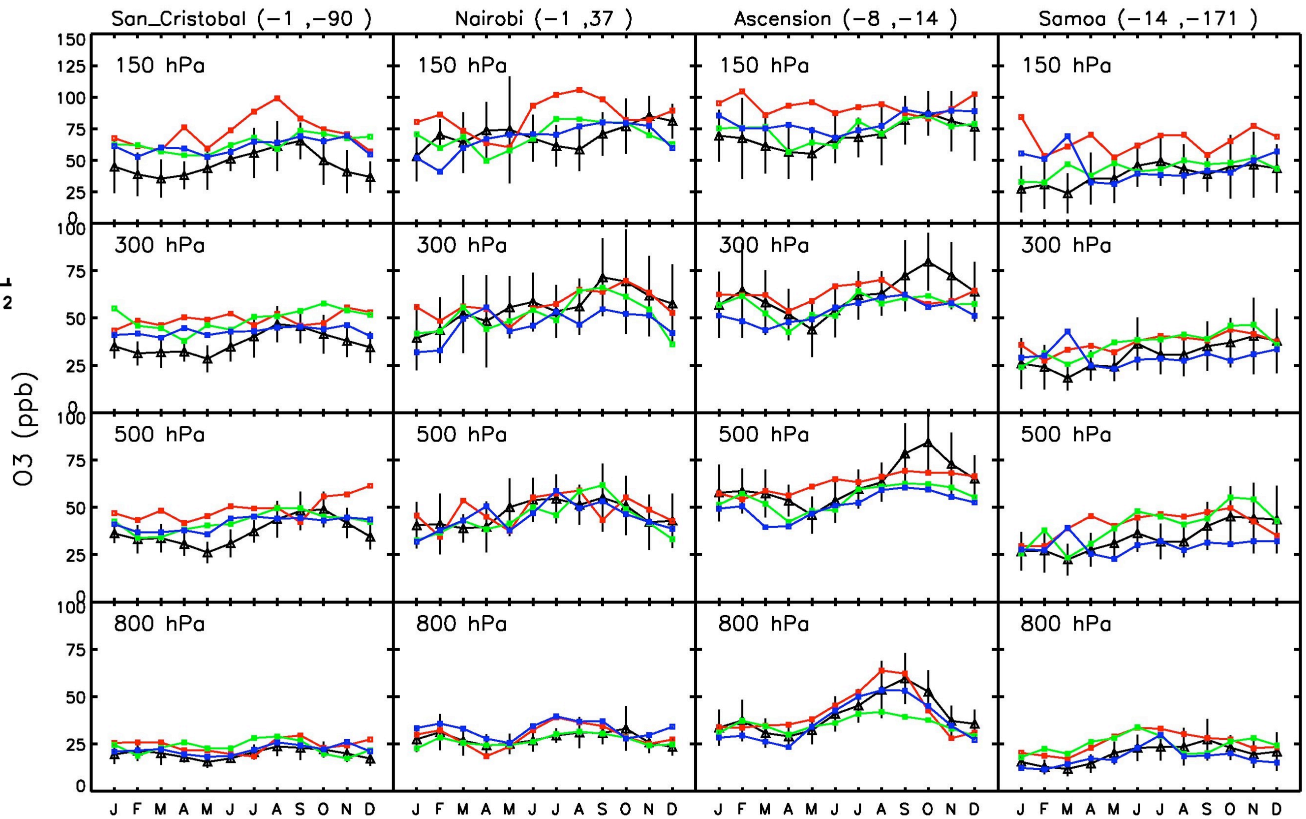
All simulations overestimate ozone in S. Asia during the monsoon

Ozone in the Tropics

CCM3
DAO
GISS

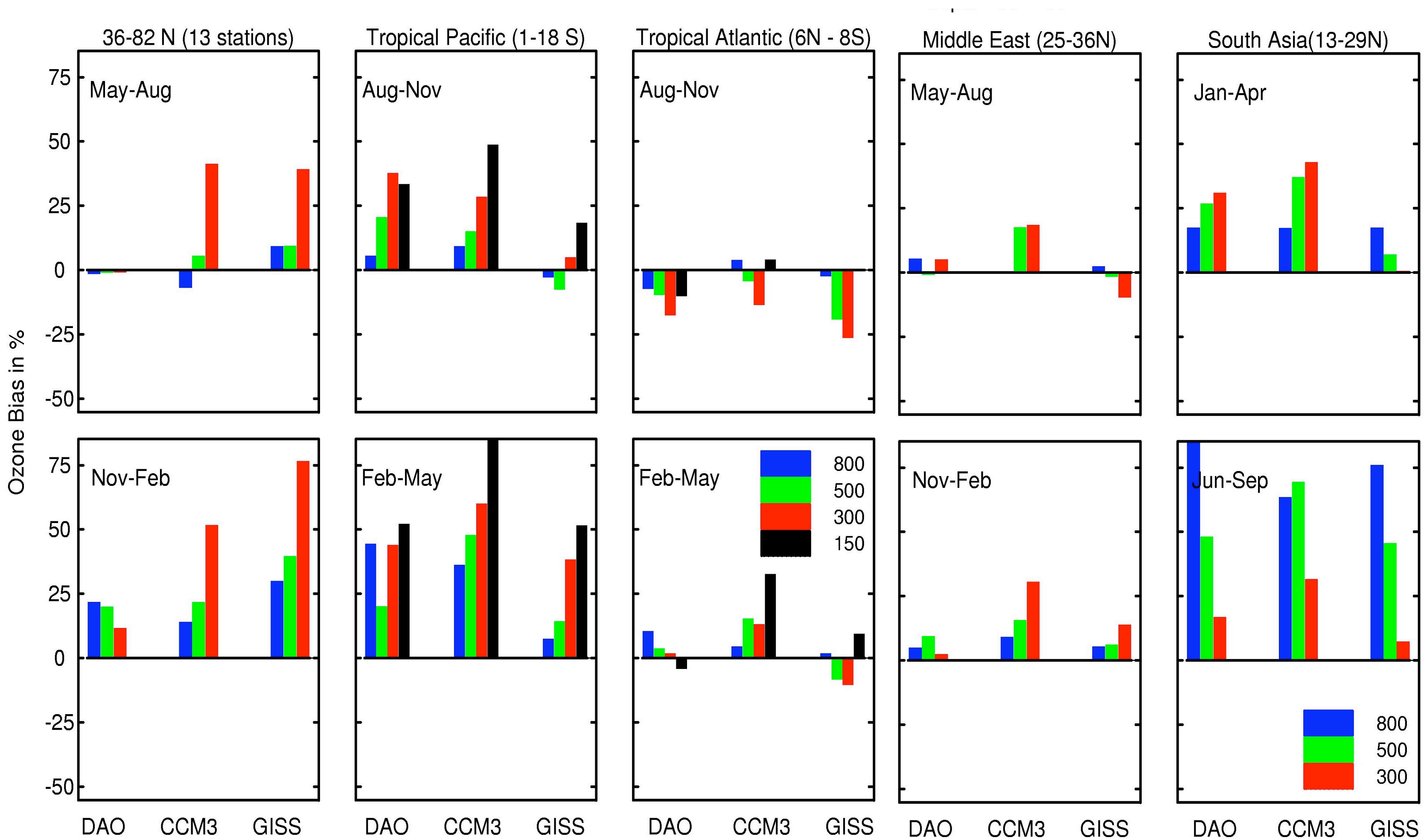
Ozone has been used as a tracer of the height of deep convection - sonde data show a relative minimum at 150-200 hPa (Folkins et al., 1999, 2002).



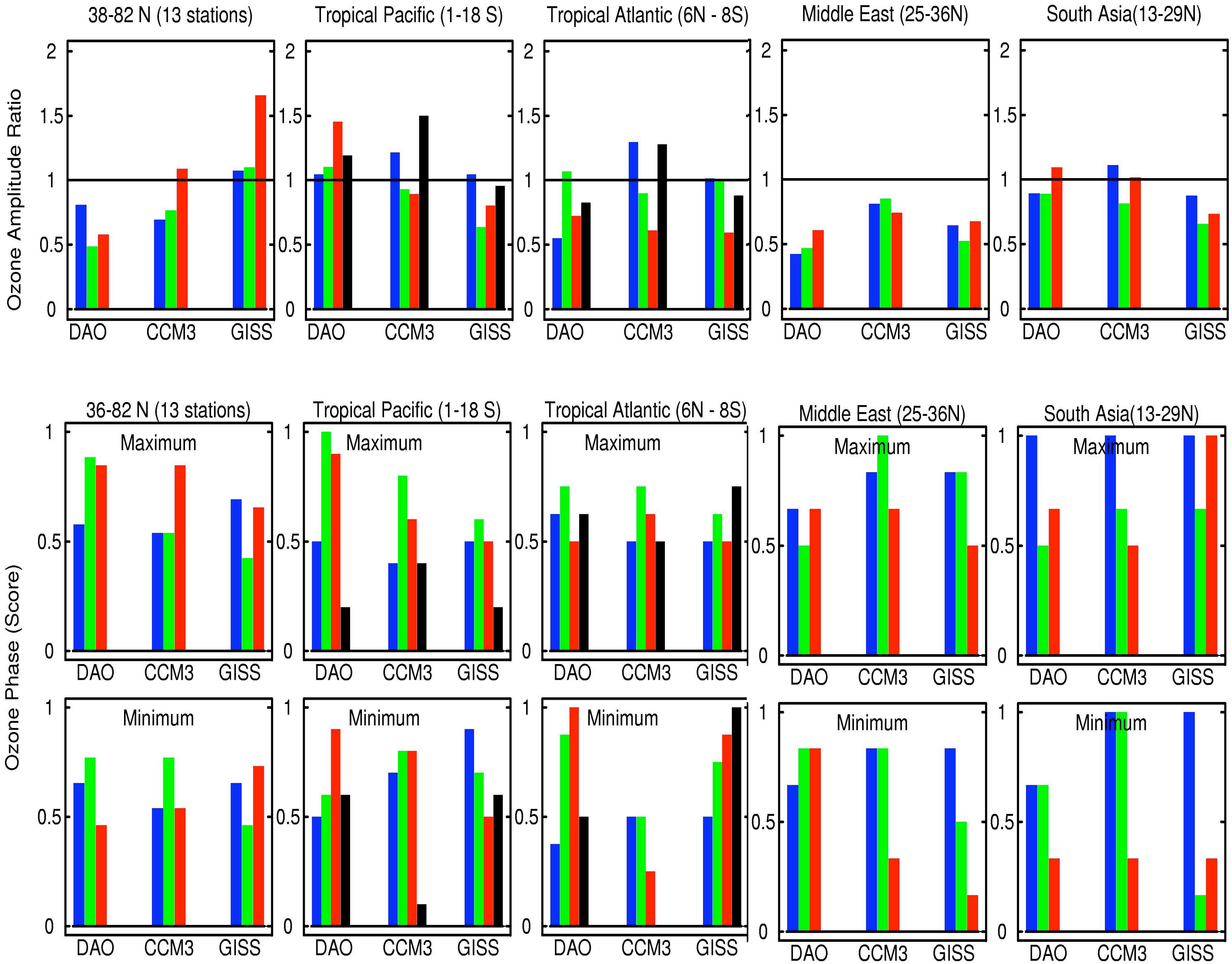


Convection in DAO, GISS appears to reach highest altitudes, CCM3 the lowest altitudes

Ozone Bias by region



Amplitude



Phase

Ozone Scores

Table 1. Scores for ozone evaluation

	DAO	CCM3	GISS	DAO	CCM3	GISS
	Ozonesonde Locations			MOZAIC Locations		
	High N. Lat., 800, 500 hPa			N. Mid. Lat, 800, 500 hPa		
Bias Score	0.88	0.88	0.63	0.87	0.83	0.85
Total Score	0.66	0.75	0.55	0.75	0.66	0.67
	Mid N. Lat., 800, 500 hPa			Middle East, 800, 500, 300 hPa		
Bias Score	0.87	0.83	0.77	0.83	0.72	0.83
Total Score	0.69	0.61	0.64	0.66	0.66	0.65
	Tropics, 800, 500, 300, 150 hPa			South Asia, 800, 500, 300 hPa		
Bias Score	0.72	0.62	0.78	0.64	0.56	0.68
Total Score	0.65	0.56	0.66	0.69	0.73	0.69
	S. Mid-high Lat., 800, 500 hPa					
Bias Score	0.85	0.85	0.47			
Total Score	0.57	0.69	0.65			

For Bias only, DAO best at N. mid-high latitudes, GISS worst
For all scores, DAO still best at mid-latitudes, CCM3 at high lat.
GISS best in tropics

Ozone

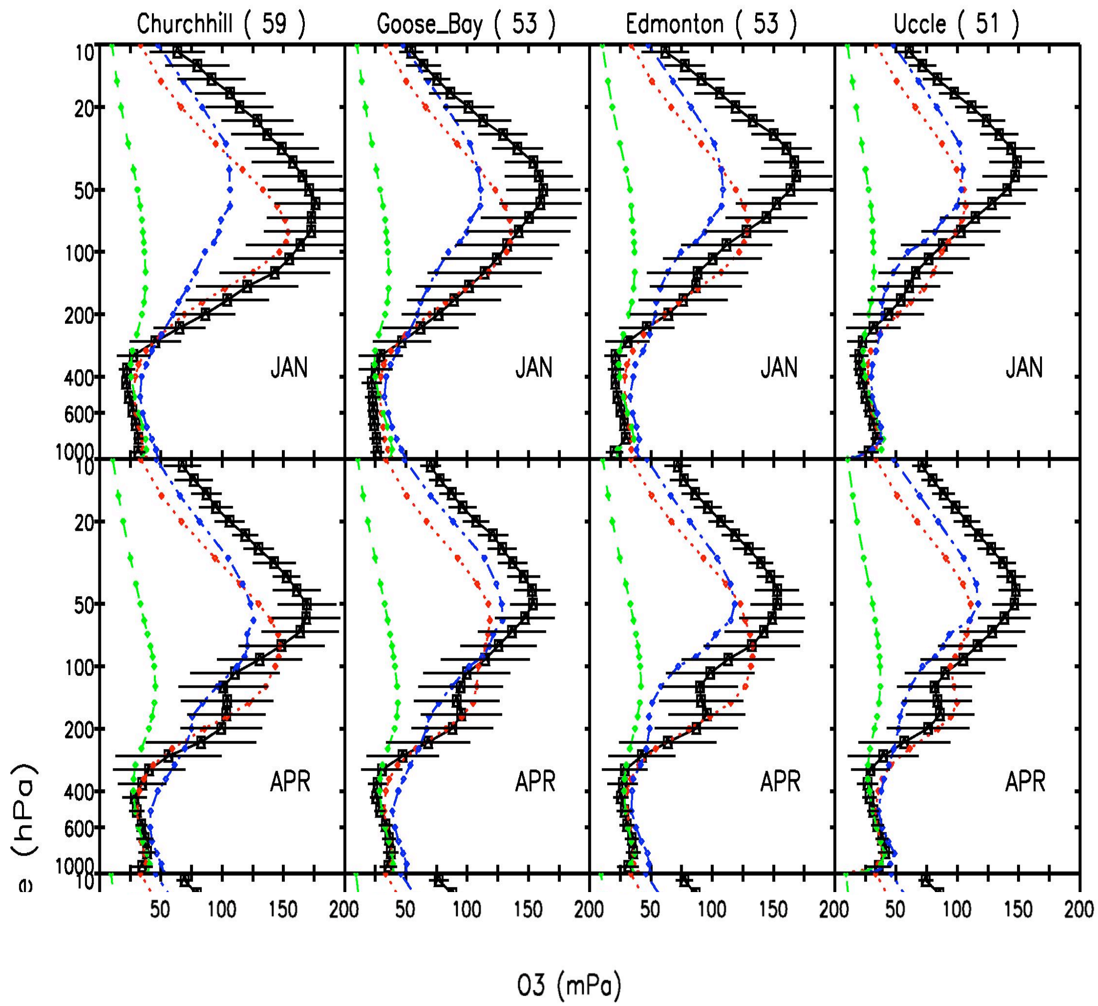
Use tracer simulations to examine two issues:

- **Stratospheric input of ozone - note that all simulations use the SYNOZ method, specifying an ozone flux of 475 Tg in the tropical stratosphere**

- **Vertical mixing in the tropics - use ocean tracer runs to look at this**

Effects of SYNOZ in LS

CCM3
DAO
GISS



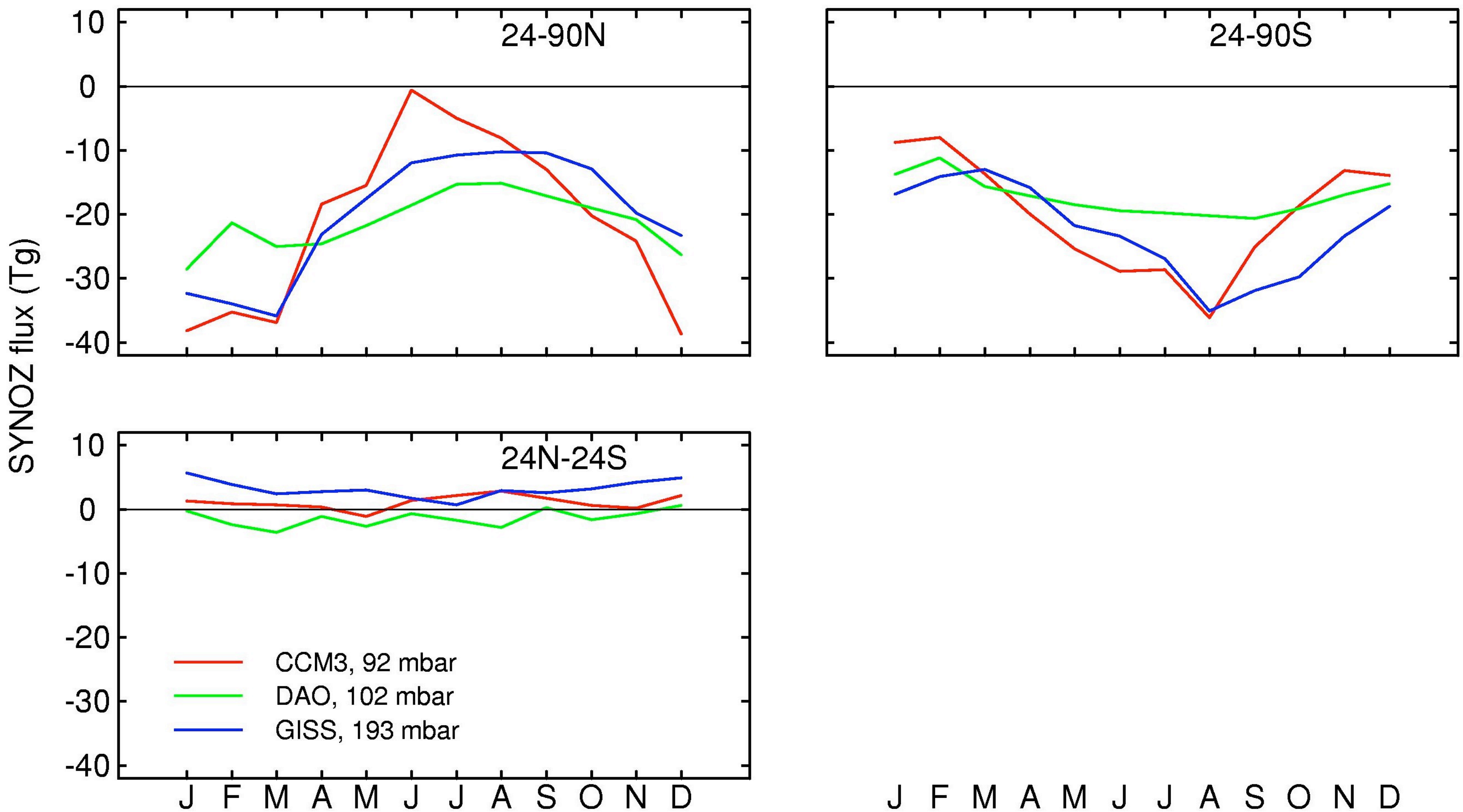
Residual circulation is much too strong in GEOS-STRAT (DAO), so SYNOZ tracer is much too low is LS.

Air mass flux too high by a factor of 3-4

SYNOZ vertical FLUX near 100 hPa vs. month

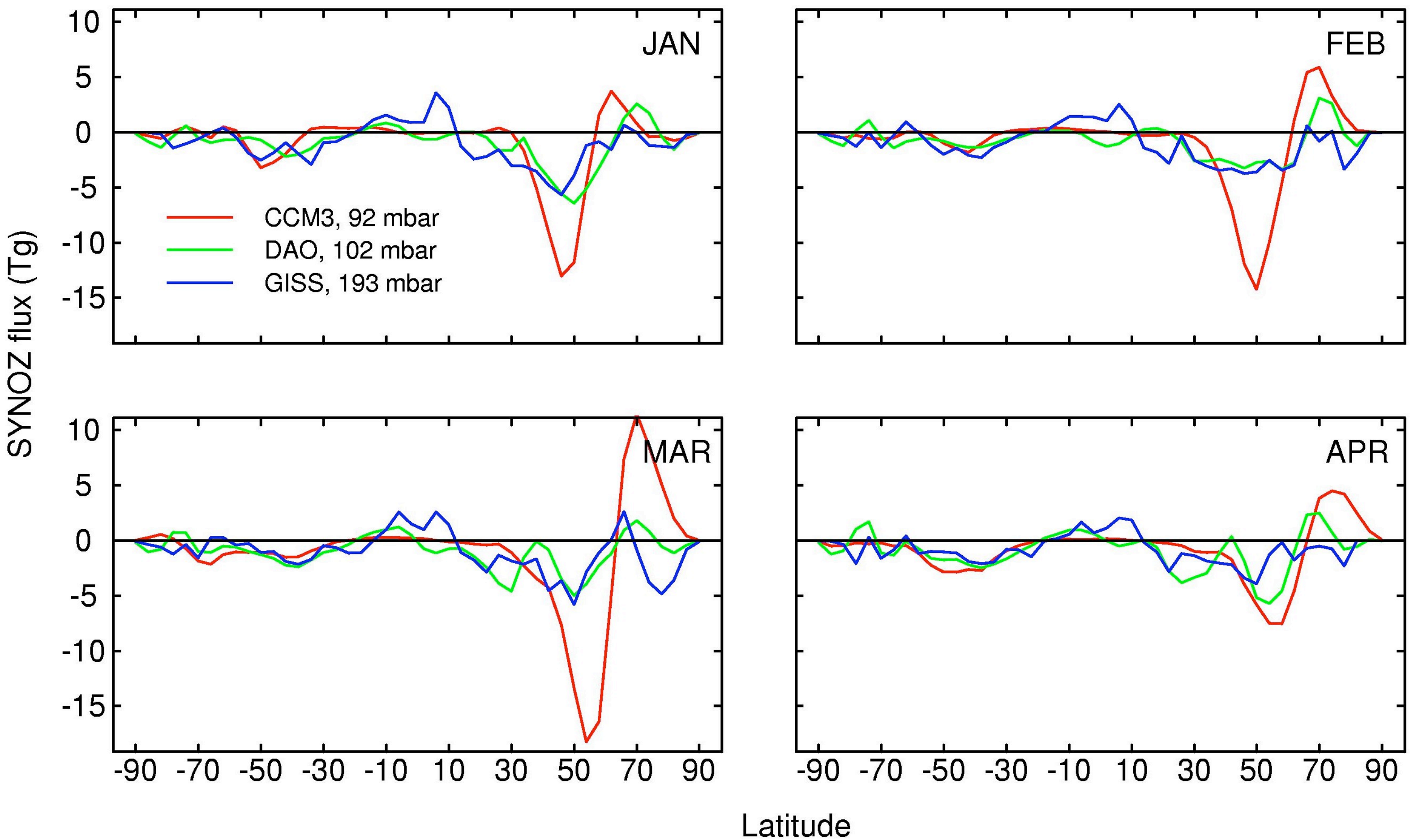
CCM3
DAO
GISS

Amplitude of the seasonal cycle for DAO is much less than for CCM3 and GISS



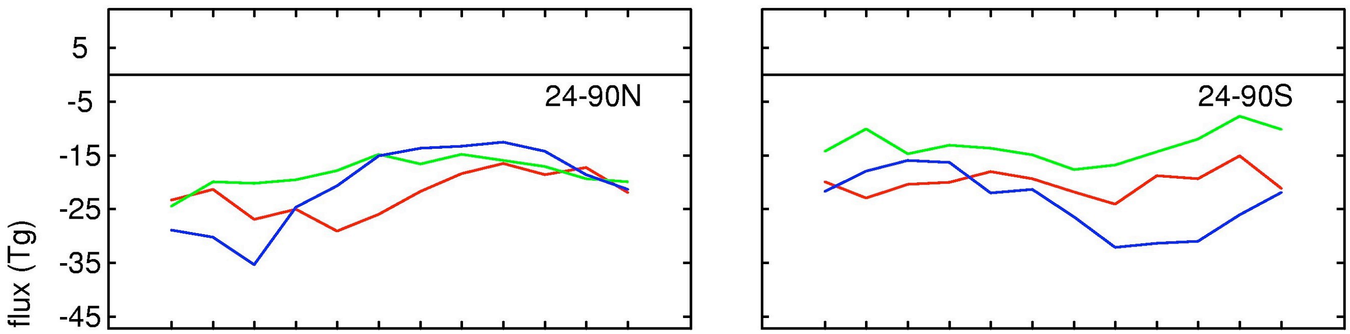
CCM3
DAO
GISS

SYNOZ vertical FLUX near 100 hPa

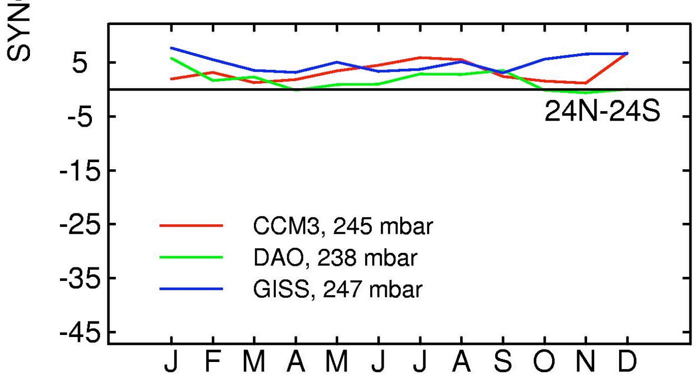


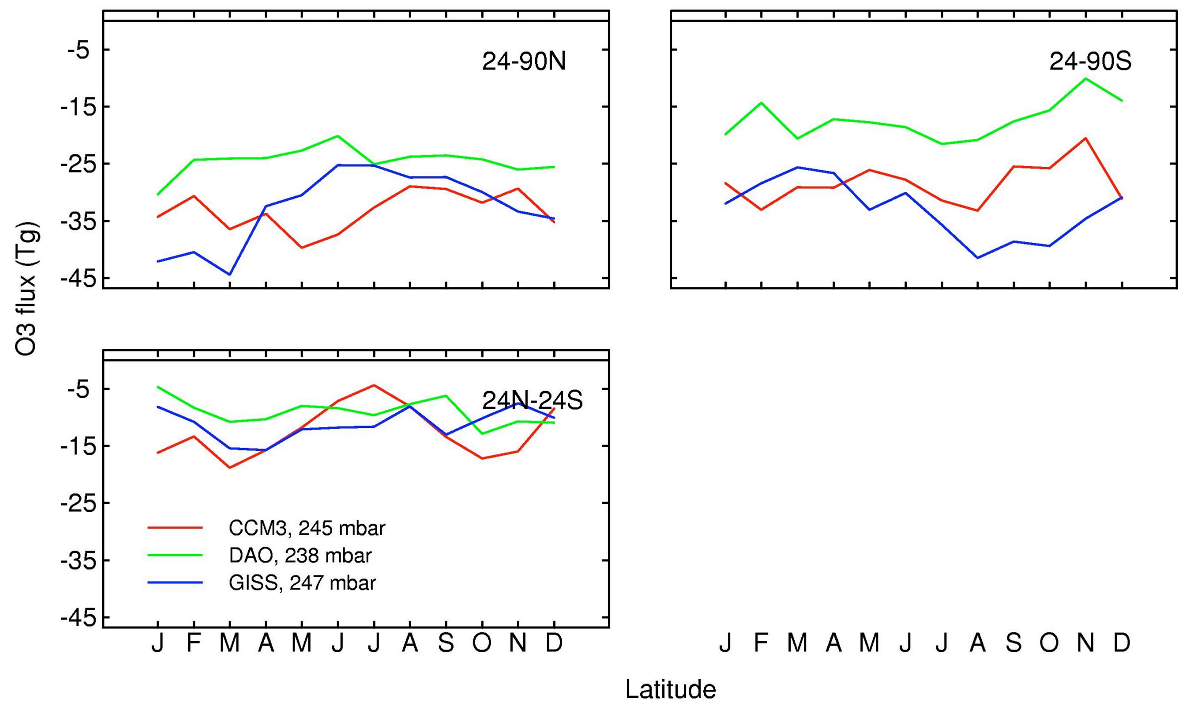
NB: GISS results for SYNOZ were not archived above 193 mb

CCM3
DAO
GISS



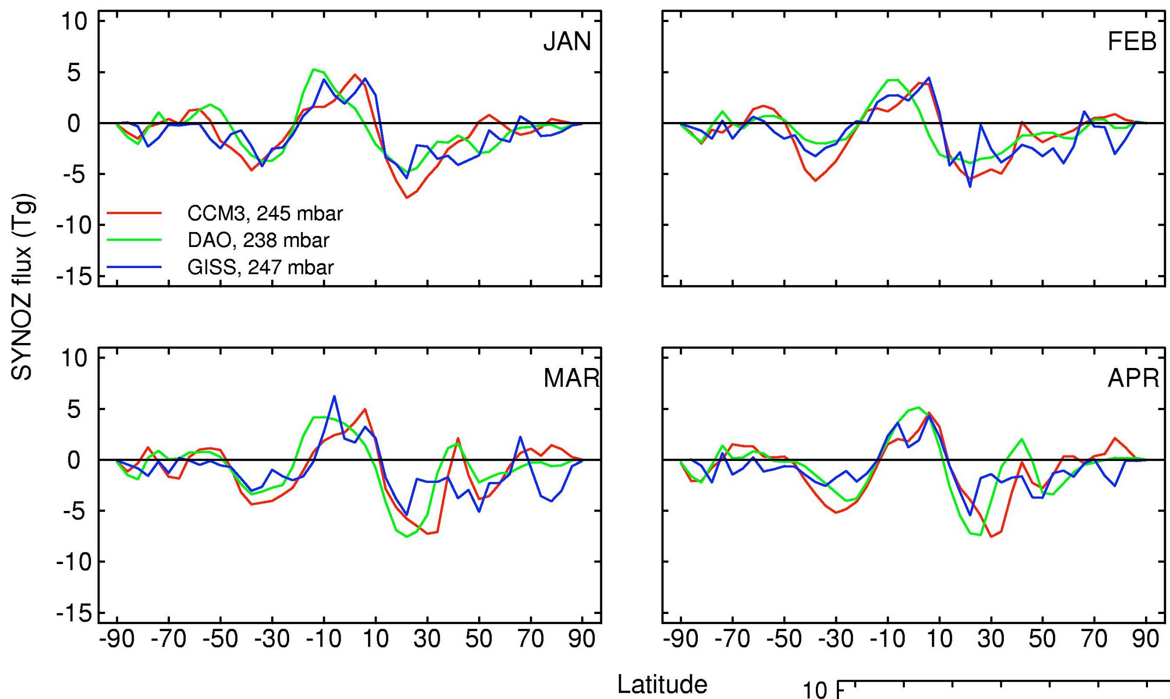
SYNOZ and ozone vertical flux near 250 hPa

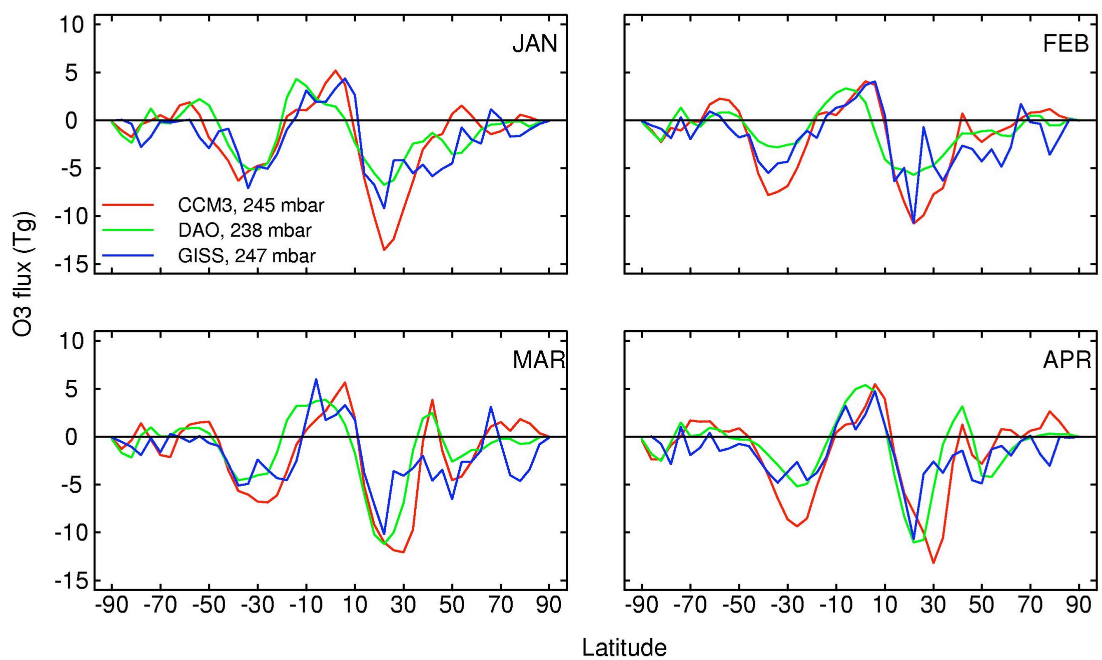


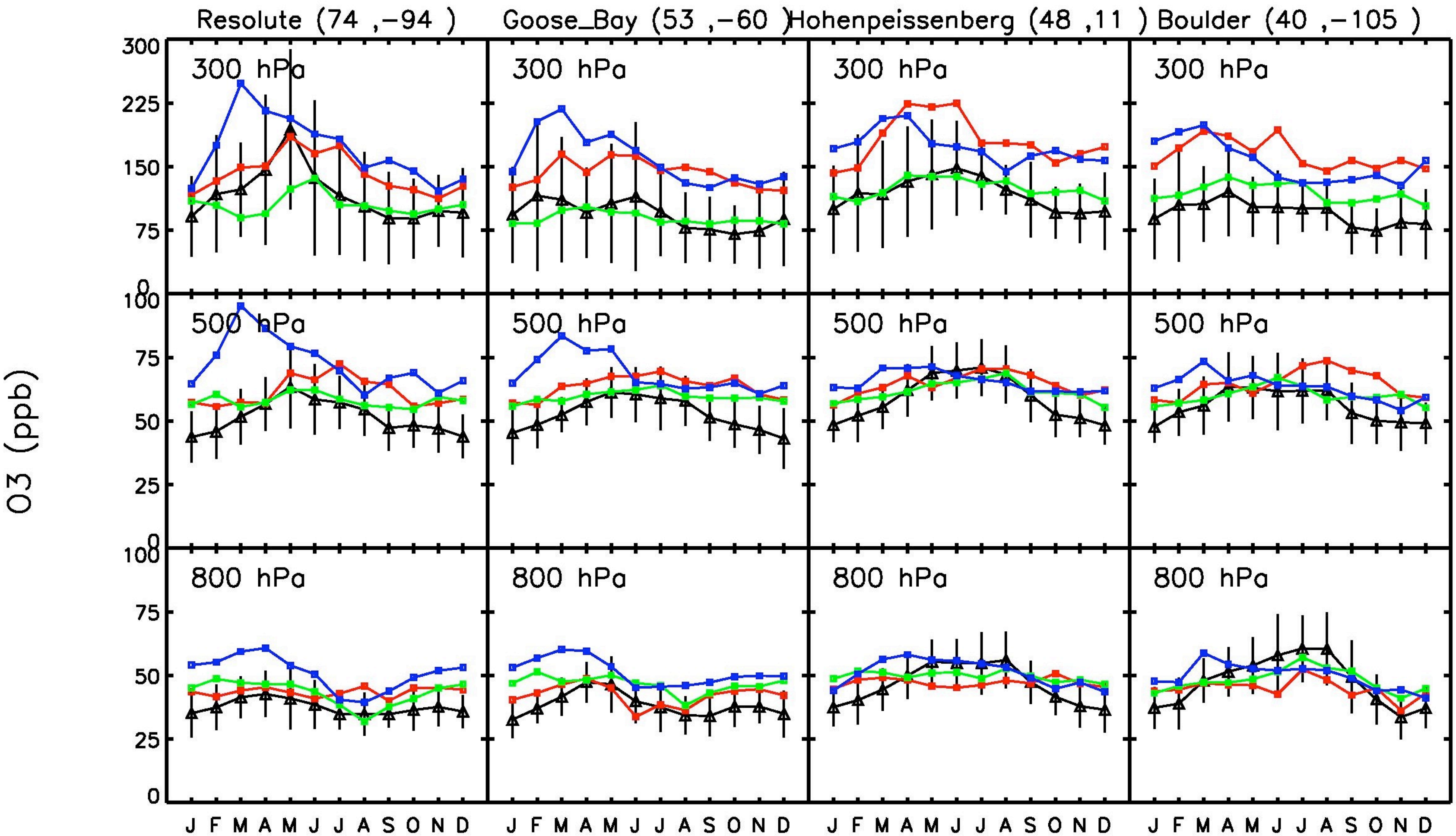


GISS has highest ozone in Jan-Mar, CCM3 in Mar-May.

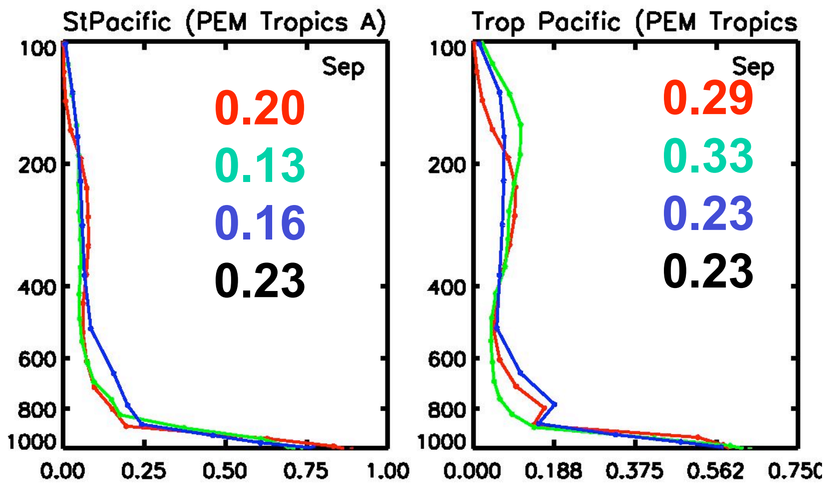
SYNOZ and ozone vertical FLUX near 250 hPa



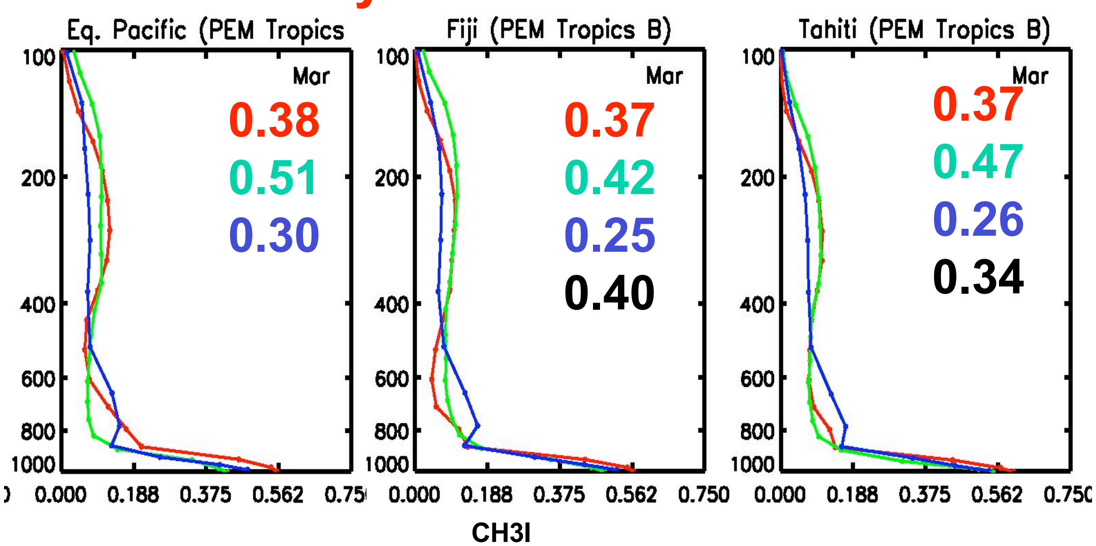



Resolute (74 ,-94)
Goose_Bay (53 ,-60)
Hohenpeissenberg (48 ,11)
Boulder (40 ,-105)
300 hPa
500 hPa
800 hPa
O3 (ppb)
0
75
150
225
300
25
50
100
J F M A M J J A S O N D

Analysis of CH3I, ocean source, 5 day lifetime



Dry Season



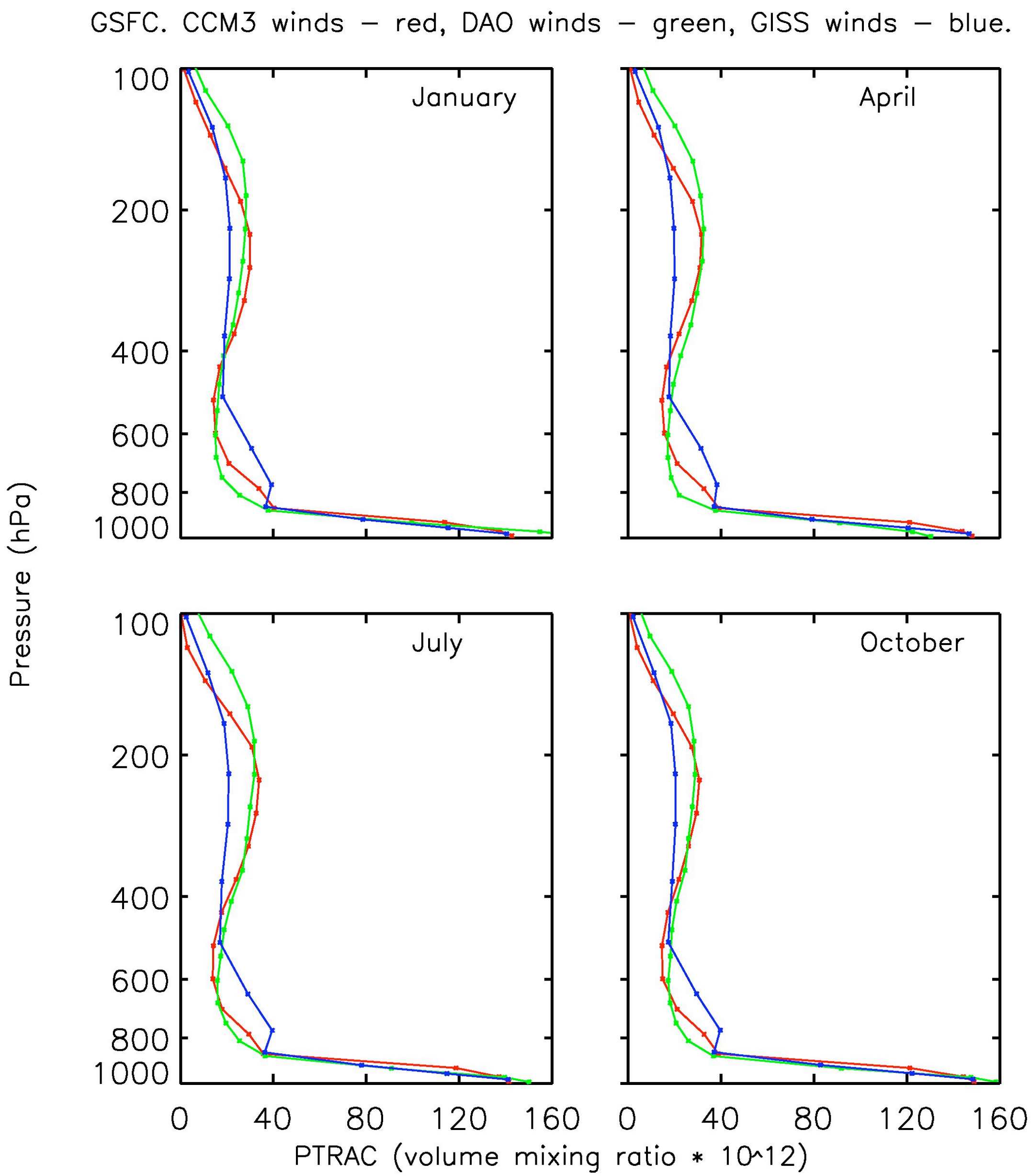
Wet Season

Vertical profiles over regions with PEM-Tropics observations (not yet on plot!)

Marine Convective Index:
UT/LT CH3I (8-12 km/0-2.5 km)
Bell et al., JGR, 2002

CCM3
DAO
GISS

Ocean tracer, 5 day lifetime - mean profiles for 16 N - 16 S

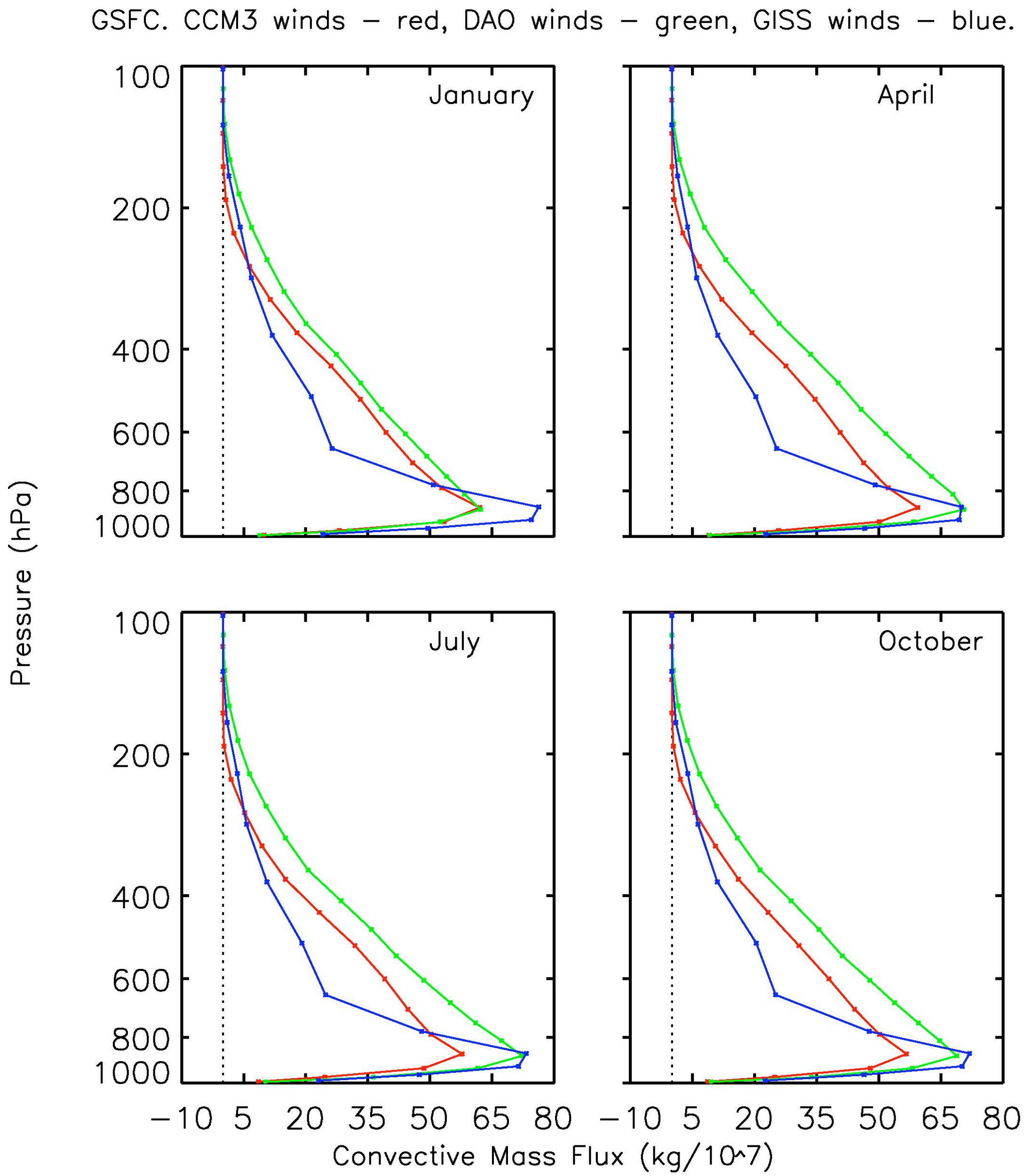


DAO has more tracer in the UT, CCM3 has least

UT maximum is at a higher altitude for DAO than for CCM3

This is consistent with patterns seen in tropical ozone (convection brings up low ozone from the marine boundary layer)

Ocean tracer with uniform source, 5 day lifetime



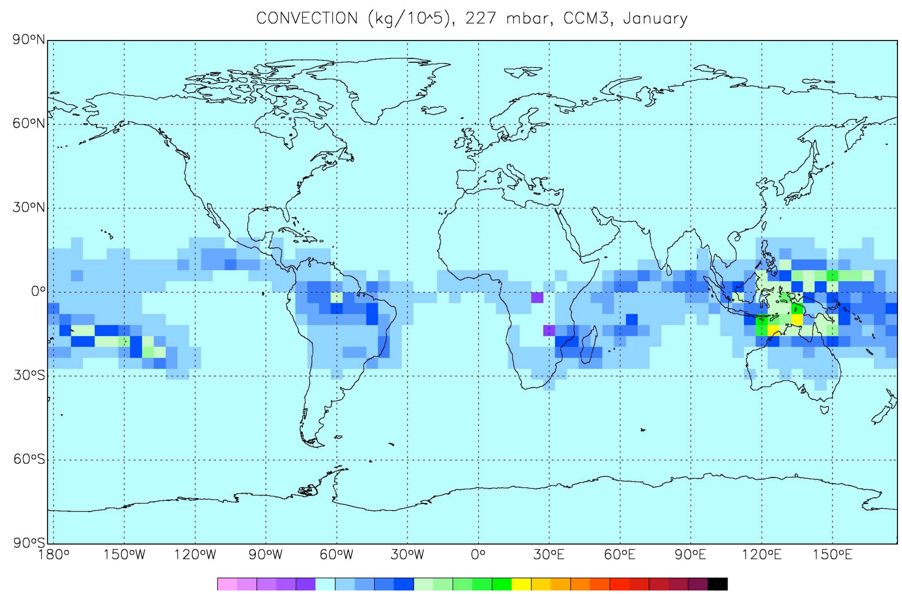
Convective mass flux of tracer for 16 N - 16 S

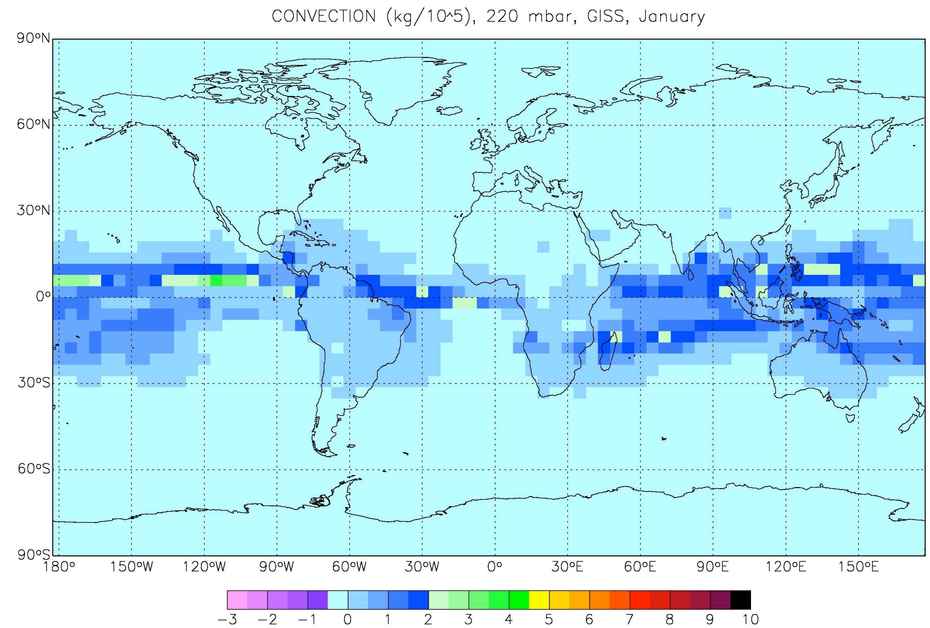
Note that convection reaches highest in DAO, lowest in CCM3

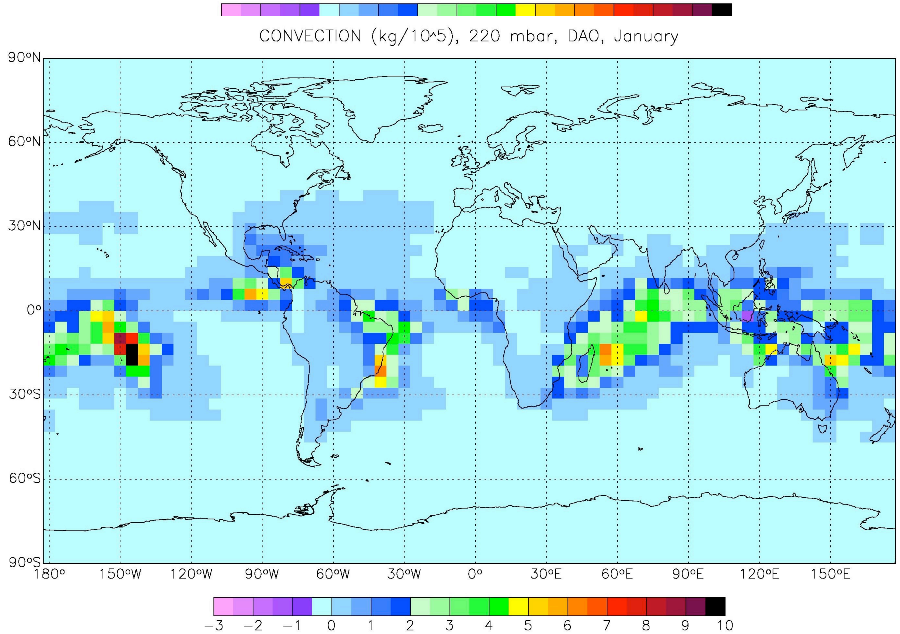
Corroborates evidence from tropical ozone profiles

Need to come up with a grade for convection based on ozone gradients in the UT

Ocean tracer: conv. flux at ~220 hPa, January



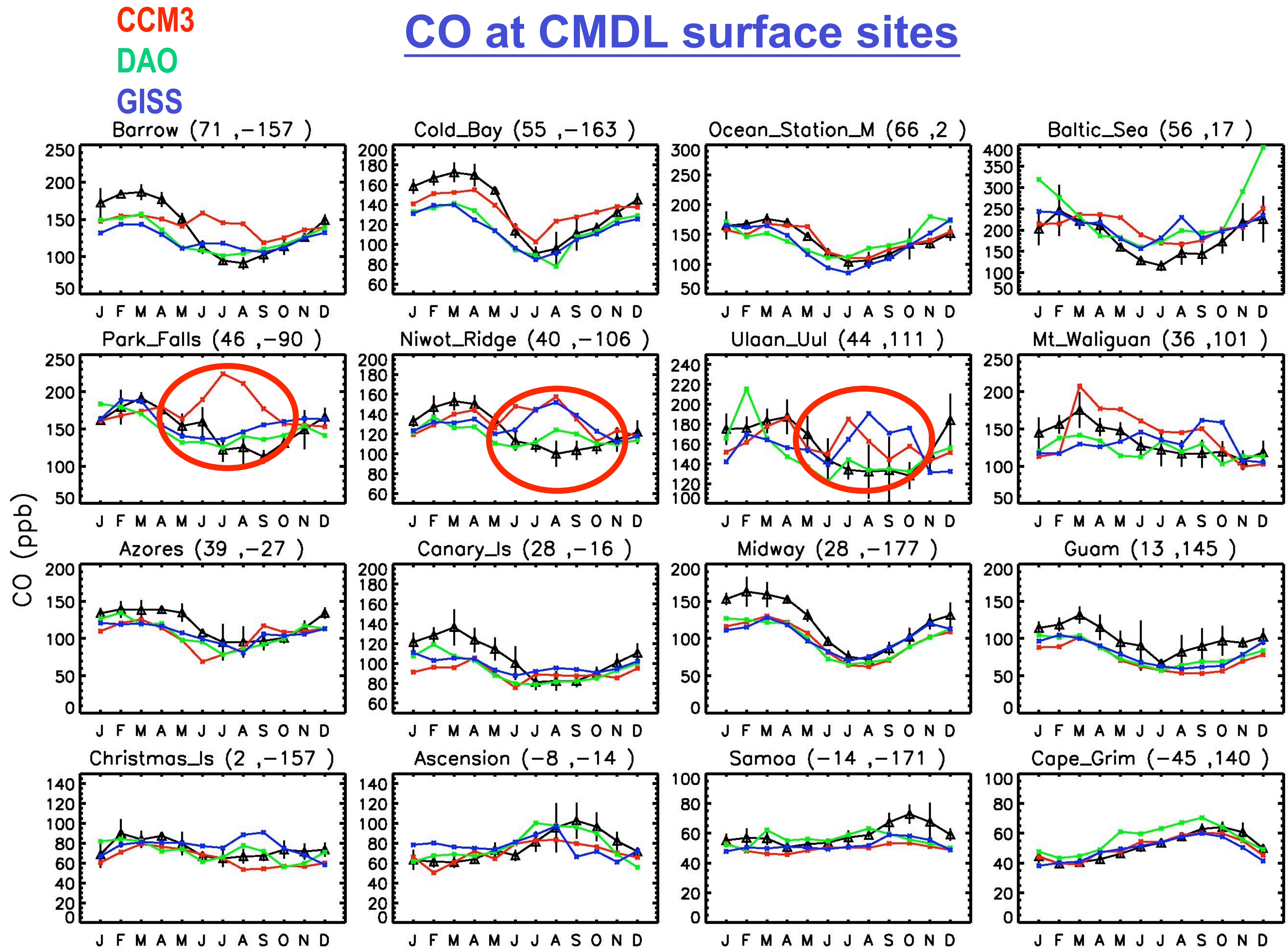




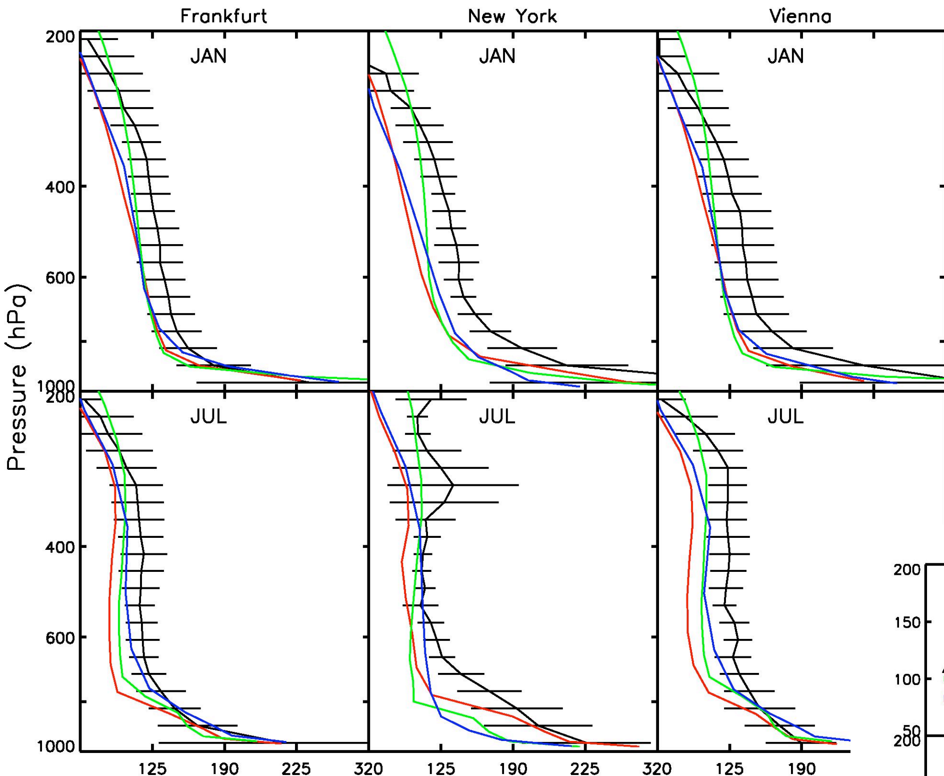
DAO run was for Mar 1997 to Feb. 1998, and so included a major El Nino for the last few months of the run.

Note the convection is shifted to the mid-Pacific in DAO

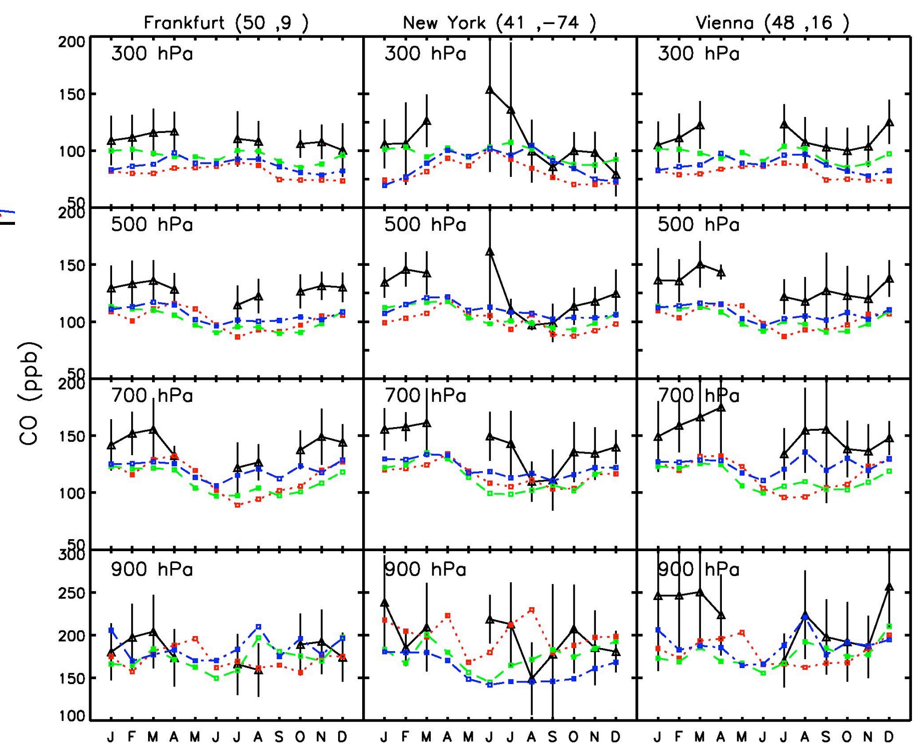
CO at CMDL surface sites



MOZAIC CO profile data

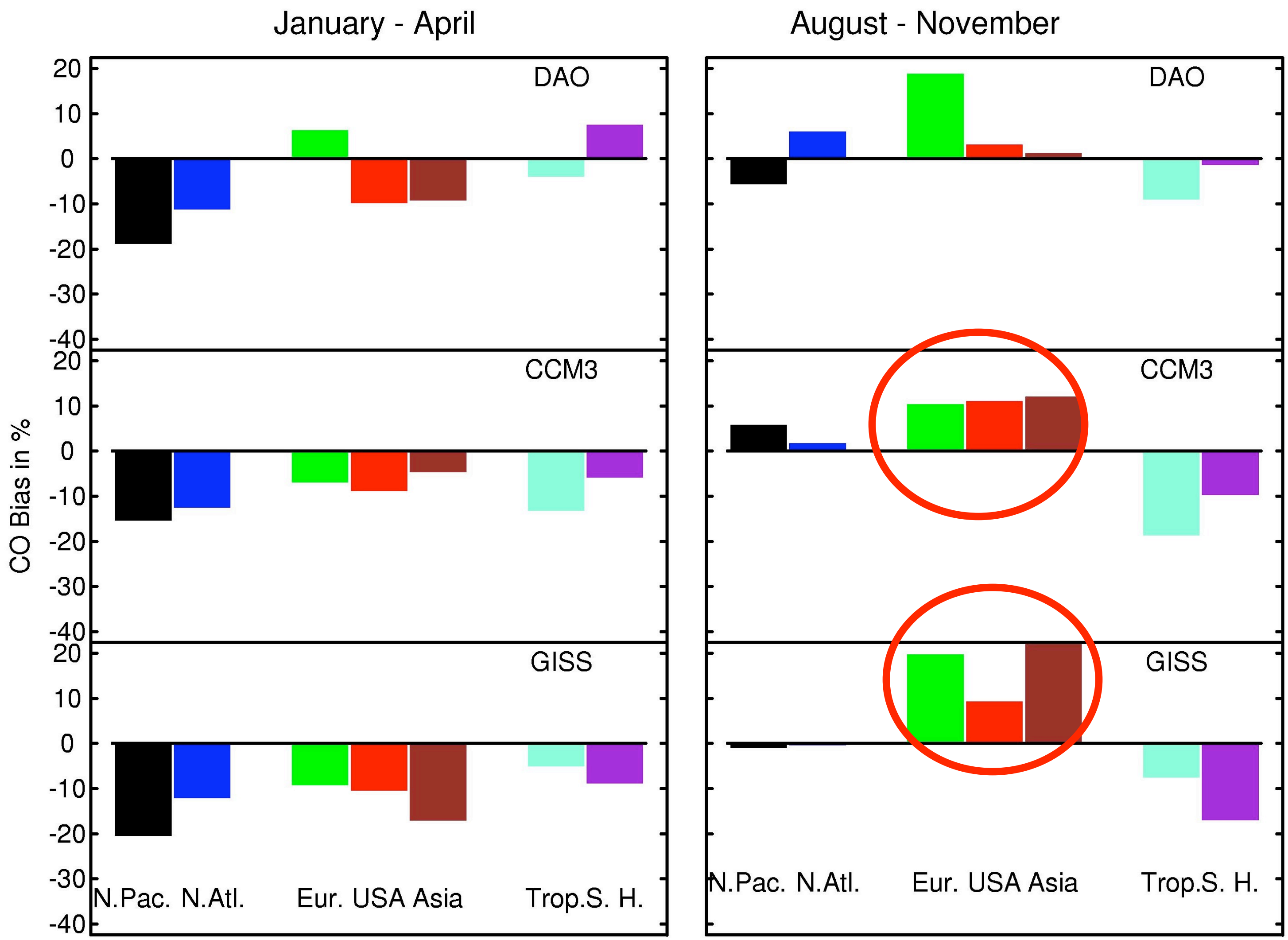


CCM3
DAO
GISS



All simulations underestimate CO above the BL. Also, models drop off too quickly in the BL compared to observations

CO Bias at CMDL sites



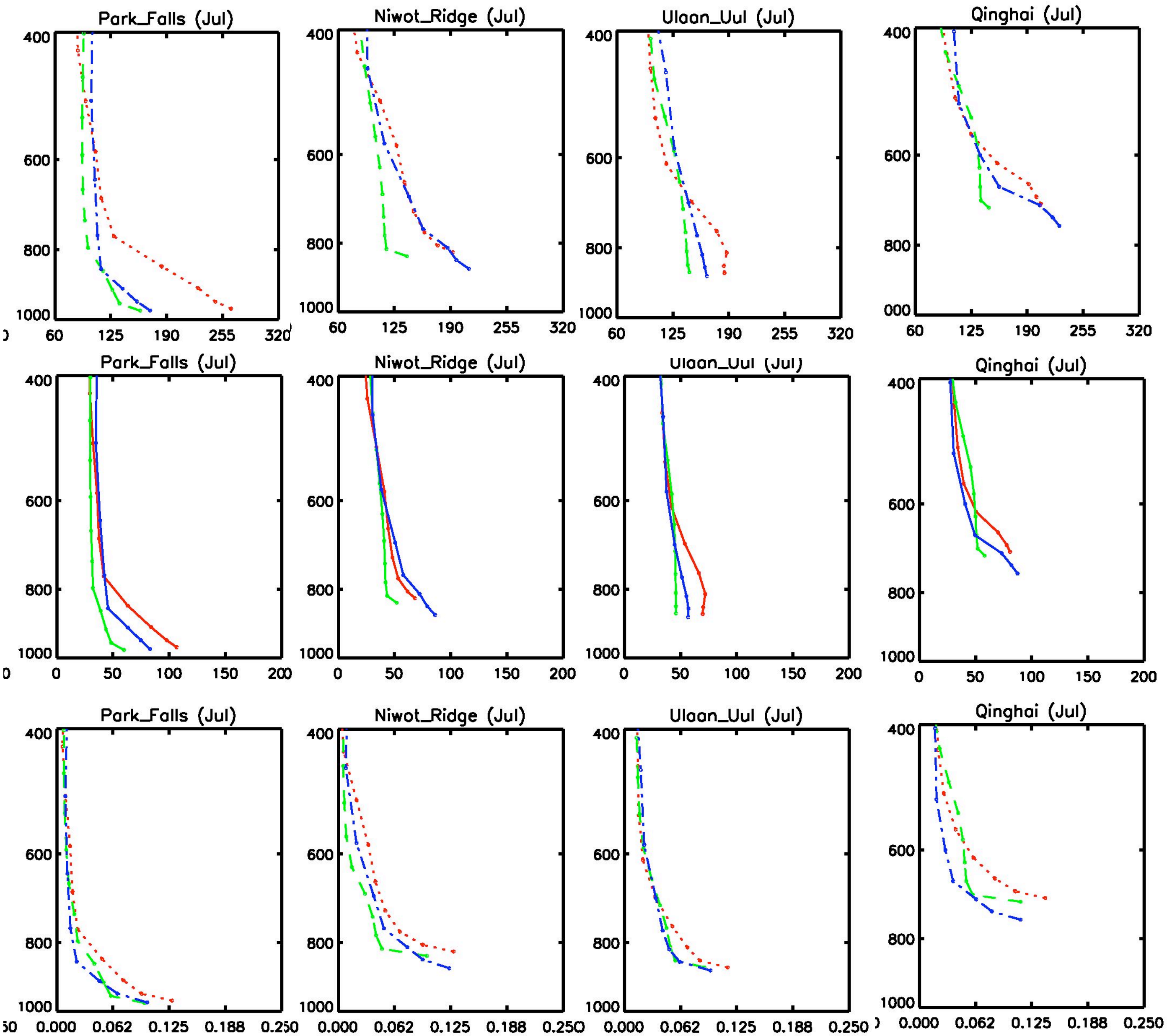
DAO

CCM3

GISS

Summer max. over continents

Why such large differences at continental sites in summer?

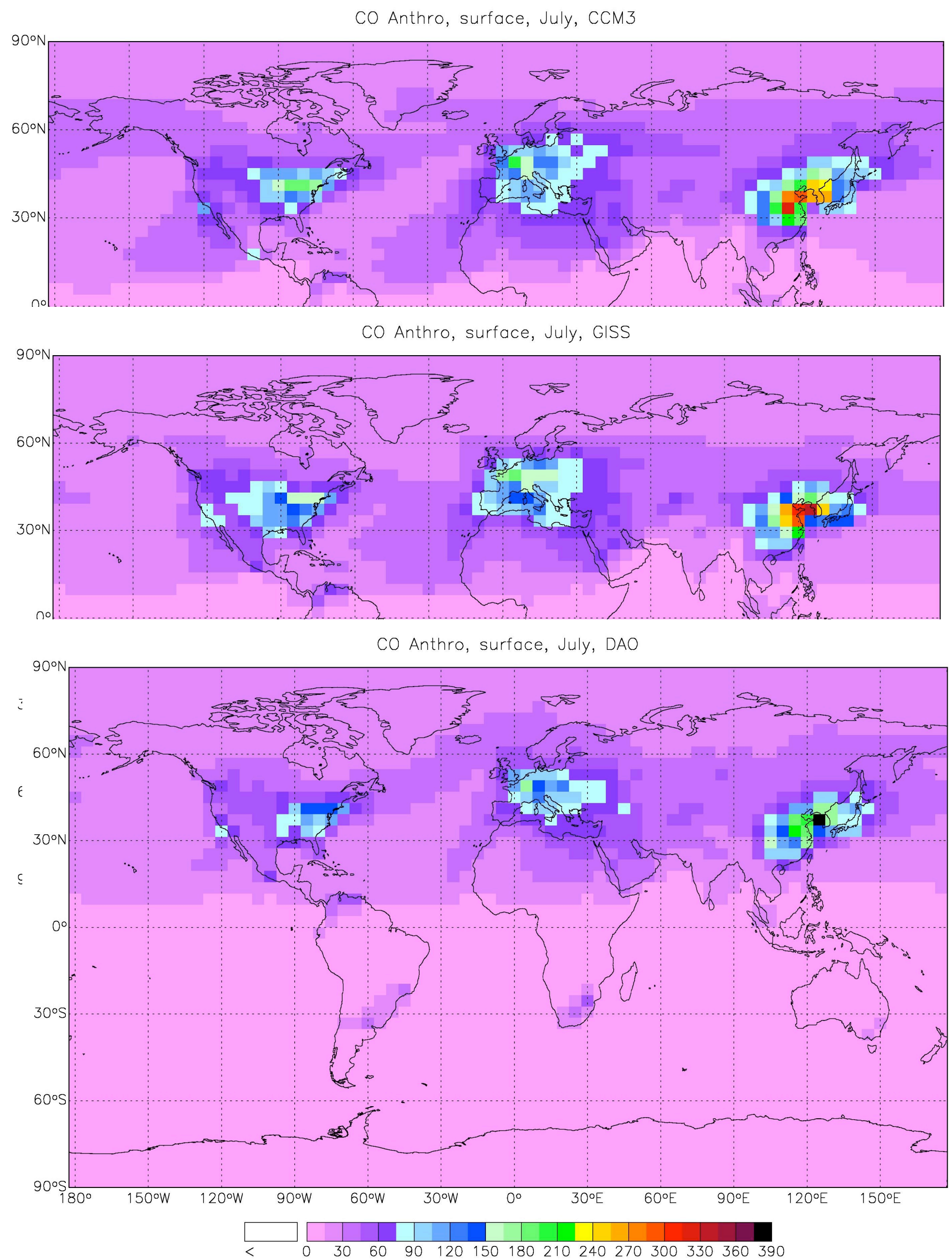


CO from std runs

CO from anthro. tracer runs

Rn tracer runs

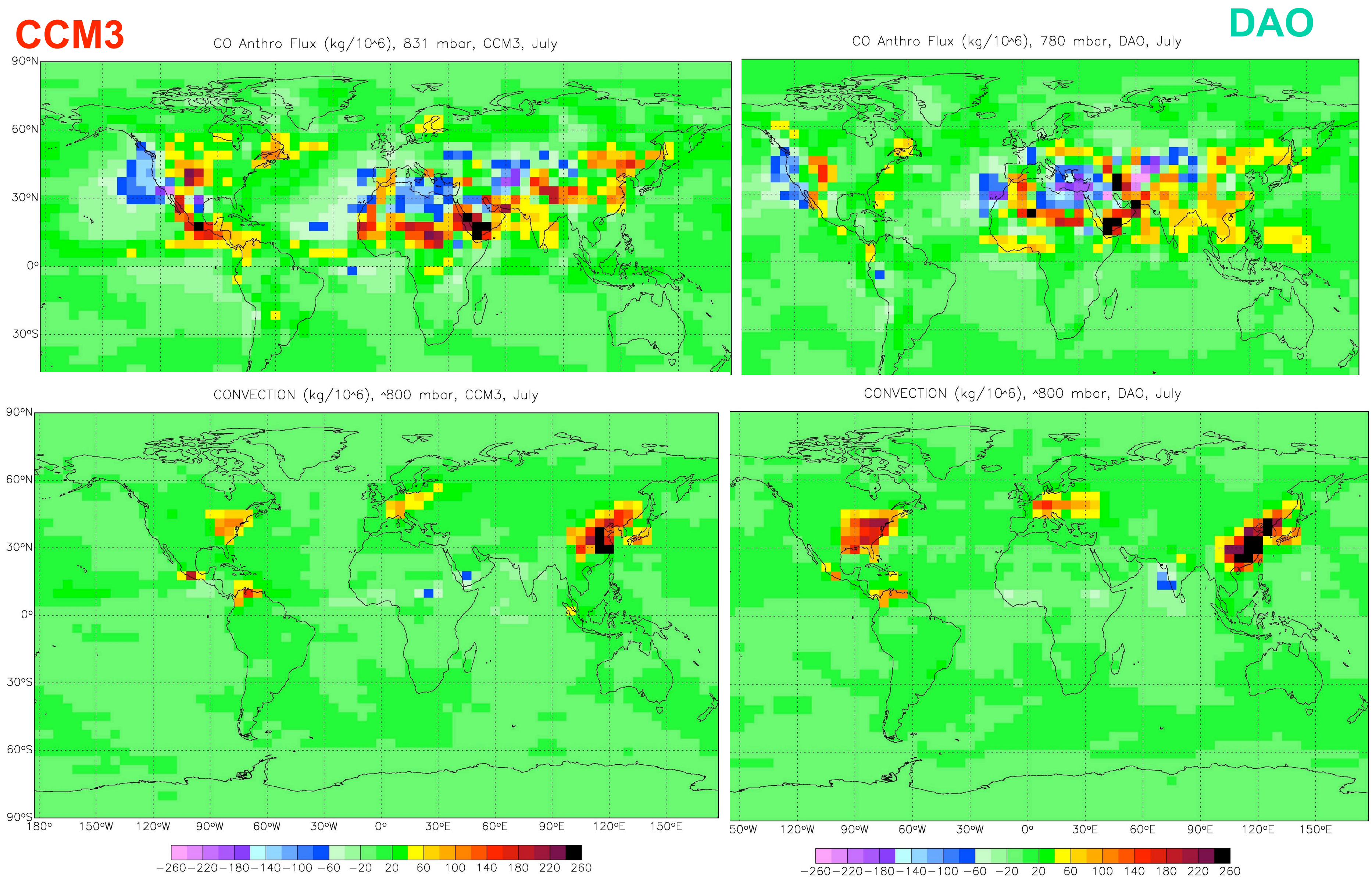
Anthro CO in July, Layer 1

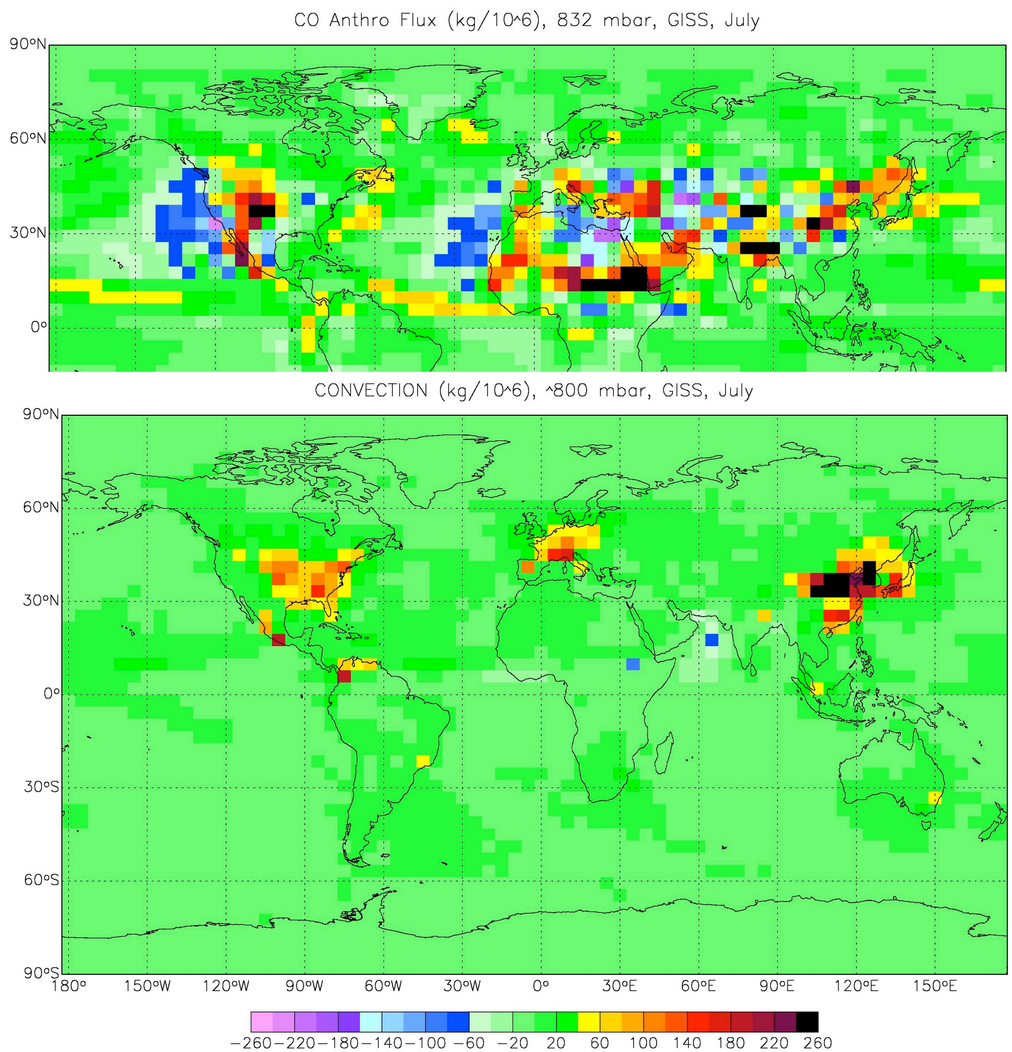


CO is lowest in DAO over source regions, CCM3 often highest

Ratio plots available, but are messy!

Vertical advective (top) and convective flux at ~800 hPa




CO Anthro Flux (kg/10^6), 832 mbar, GISS, July
90°N
60°N
30°N
0°
CONVECTION (kg/10^6), ^800 mbar, GISS, July
90°N
60°N
30°N
0°
30°S
60°S
90°S
180°
150°W
120°W
90°W
60°W
30°W
0°
30°E
60°E
90°E
120°E
150°E
−260 −220 −180 −140 −100 −60 −20 20 60 100 140 180 220 260

Conclusions from preliminary analysis of tracer runs

- **Differences in convection are responsible for the major differences in CO over continental source regions**

- **Differences in convection are responsible for different profiles in the UT for tropical ozone**

- **Much remains to be done to determine why the models differ for the full chemistry simulation**